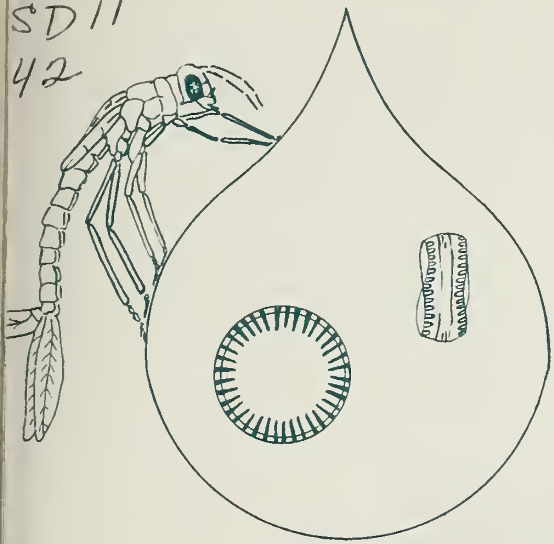

Aquatic Biota of Trout Creek, Manitou Experimental Forest, Colorado

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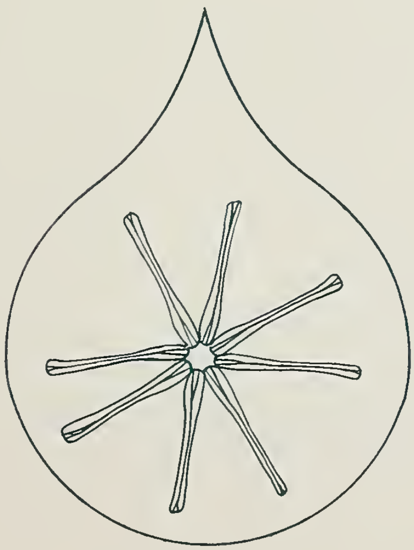

General Technical Report RM-54
Rocky Mountain Forest and
Range Experiment Station
Forest Service
U.S. Department of Agriculture

ABSTRACT

A survey of macroinvertebrates, periphyton and fishes in Trout Creek and in two of its tributaries was conducted from June through October 1976. Identified were 57 genera of algae, 5 species of fish and 78 taxa of macroinvertebrates. A generally diverse and abundant aquatic fauna and flora prevailed at most study locations. A site below a surface-release reservoir (Manitou Lake) exhibited reduced macroinvertebrate diversity, although standing crop was enhanced, presumably due to contributions of limnetic seston from the lake, compared with other sites on Trout Creek. Species diversity and equitability index values did not indicate any significant degradation of water quality.

General Technical Report RM-54 February 1978

Aquatic Biota of Trout Creek, Manitou Experimental Forest, Colorado

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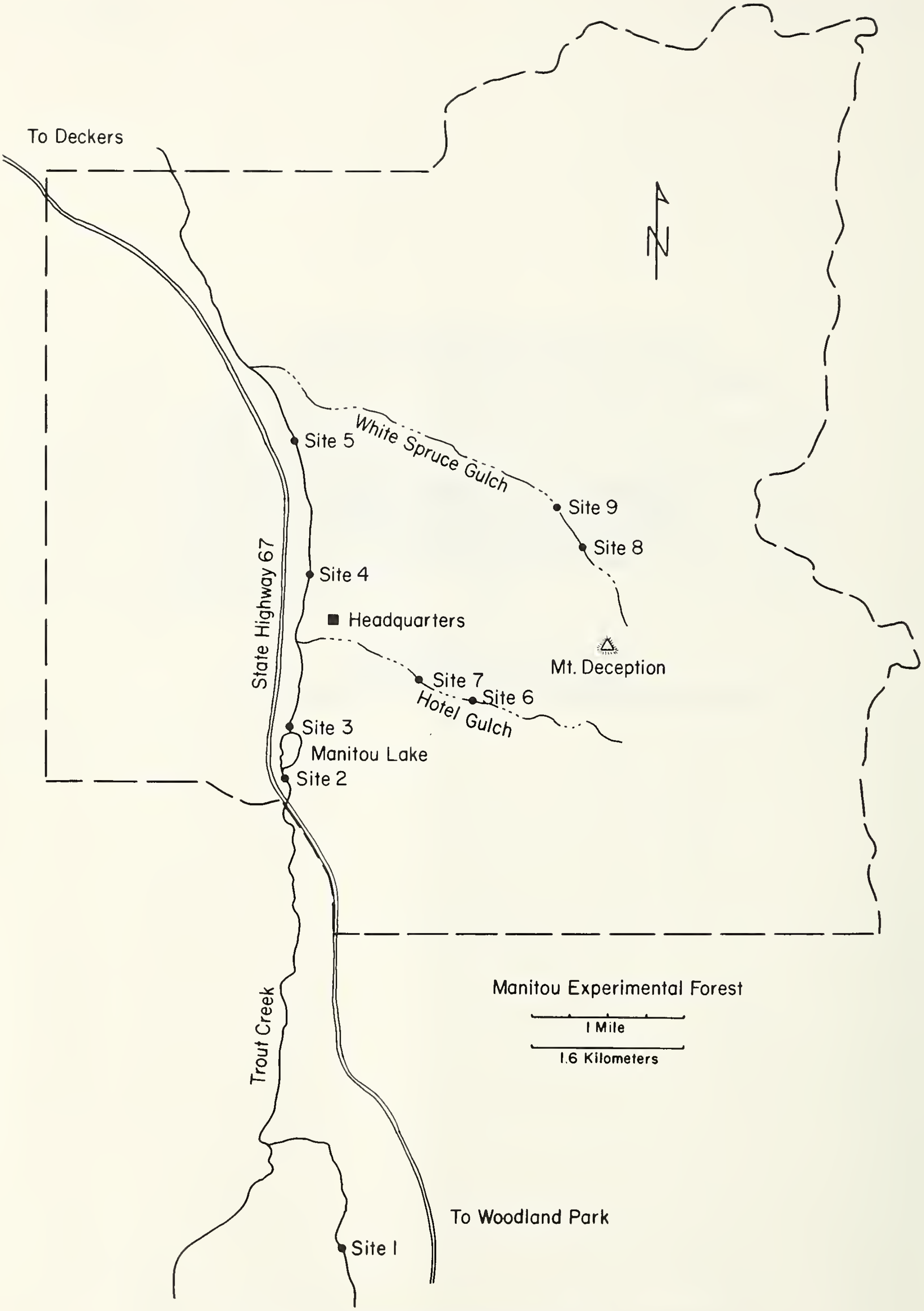

Figure 1.—Location of study sites.

Aquatic Biota of Trout Creek, Manitou Experimental Forest, Colorado

Robert A. Short, James V. Ward, Howard L. Gary, and Pat O. Currie

The rapid and continuing economic expansion along the Front Range of the Colorado Rocky Mountains has complicated the management of all natural resources, especially maintaining or improving the quality of limited water resources. Alterations in the natural environment, such as road building, mountain home developments, reservoir construction, etc., coupled with highly erodible lands and low annual rainfall (350-500 mm) and streamflow (80 mm depth) dictate an urgent need for broad-based research. Quality indexes must be established; land management guidelines to protect the purity of headwater streams should be set.

It is often difficult to determine how water quality may be affected by upstream landuse. Intermittent extreme pollutant discharges into a stream may go undetected due to widely varying intervals for sampling water. An alternate procedure to determine water quality over a period of time is the study of various aquatic biota (Goodnight 1973) which, due to their relatively low motility, register changes in their environment for long periods of time.

This Paper reports a survey made during the summer and fall of 1976 of macroinvertebrates, periphyton and fishes in Trout Creek, a major headwater stream, and in two intermittent tributary streams of Trout Creek. The objective was to gain a basic understanding of the existing stream ecosystems prior to an expected expansion in mountain home developments on private lands within the Manitou Experimental Forest and on other adjacent private lands.

Site Description

Trout Creek is a tributary of the South Fork of the South Platte River. Flowing in a northerly direction, it primarily passes through coarse-textured alluvium derived from disintegrated Pikes Peak granite washed down from the mountain slopes. The study section was located in the montane life zone (fig. 1) in the Manitou Experimental Forest, about 15 km NNW of Woodland Park, Colo. The highest elevation of the drainage is 2,865 m.

Site 1, the only site not located in the Forest, had an elevation of 2,454 m. Since it represented the most natural, unimpacted reaches of the stream, it was the control site for the study. The forest cover nearest the stream was mainly Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), blue spruce (*Picea pungens* Engelm.), and Engelmann spruce (*Picea engelmannii* Parry) with ponderosa pine (*Pinus ponderosa* Laws.) on the drier sites above the floodplain (fig. 2). The site was almost completely shaded by willows (*Salix* spp.) and thinleaf alder (*Alnus tenuifolia* Nutt.). The substrate was composed of angular granitic rubble embedded in sand and gravel.

Sites 2 and 3 were located about 4 km downstream from site 1 at elevations about 2,358 m. Site 2 was immediately upstream of Manitou Lake and site 3 immediately below the lake. The substrate at site 2 was composed of sand and gravel and covered with a thin layer of silt. Rubble was placed in the stream at site 2 in

Figure 2.—Site 1 was located at a relatively unimpacted area on Trout Creek. The stream is perennial from this area to its confluence with the South Platte River.

order to reduce substrate variability between sampling sites 2 and 3. Periphyton (algae) and macroinvertebrates rapidly colonized the rubble, which remained relatively silt-free until a beaver dam was constructed about 30 m upstream of the site in early August. The substrate at site 3 was composed of sand and gravel overlain with rubble. Some silt was also present. Vegetation at sites 2 and 3 consisted mainly of willows, grasses, sedges and rushes.

Site 4 was located about 3 km downstream from Manitou Lake at an elevation of 2,235 m and site 5 about 1.3 km further downstream at an elevation of 2,330 m. Rubble was placed in the stream at site 5 to make it more comparable to site 4. At these sites Trout Creek flows through a broad alluvial floodplain and bank sloughing is common to the area (fig. 3). The land area between sites 4 and 5 is native pasture that has been moderately grazed by 40-50 head of cattle during the spring for the past several years. It is the only source of water for the cattle which have full access to the stream.

Site 6 was located above and site 7 below four primitive cabins occupied during the summer on Hotel Gulch, an intermittent tributary of Trout Creek. The horizontal distance between the sites was about 0.5 km. The elevation of sites 6 and 7 was 2,523 and 2,462 m, respectively. Both sites were shaded by Douglas-fir, quaking aspen (*Populus tremuloides* Michx.), thinleaf alder, water birch (*Betula occidentalis* Hook.), common chokecherry (*Prunus virginiana* L.) and willows. The substrate at both sites was gravel, sand and rubble. Moss (*Fontinalis* spp.) covered the substrate at site 6 and accumulations of fallen leaves were common at site 7.

Sites 8 and 9 were located on White Spruce Gulch, another intermittent tributary of Trout Creek. Both sites are located in a unimpacted area of the Manitou Experimental Forest. Distance between the sites was 0.4 km. Elevation at sites 8 and 9 was 2,520 and 2,455 m, respectively. The vegetation at both sites was similar to that observed at sites 6 and 7. Various grasses and forbs were also abundant. The substrate was bedrock, rubble with sand, and gravel. The rocks were generally free of algae and silt, although some surfaces were colonized by moss.

Methods

Macroinvertebrates were sampled monthly at the Trout Creek sites using a Surber stream-bottom sampler. The sampler enclosed an area of 929 cm^2 (1-ft^2) with net openings of 250 μm. All samples were preserved in 5% formalin. Qualitative macroinvertebrate samples were also taken monthly from sites on the two intermittent streams. The samples were obtained by collecting leaf packs or moss, or by disturbing the substrate and collecting the dislodged organisms in a net.

Figure 3.—Sites 4 and 5 were in an area of unstable streambanks along the broad alluvial floodplain of Trout Creek.

In the laboratory the organisms were separated from the detritus and placed in 80% ethyl alcohol for identification and enumeration. No numerical analyses were performed on samples from the intermittent streams. Biomass for the invertebrates was determined by volumetric displacement assuming a specific gravity of 1.0. Diversity was calculated from the formula:

$\bar{d} = 3.3219/N\ (N \log_{10} N - \Sigma n_i \log_{10} n_i)$ where:
- 3.3219 = conversion factor to base 2 logarithms
- N = total number of individuals
- n_i = total number of individuals of i^{th} taxa.

Diversity indices provide a measure of quality of the environment and the effects of induced stress on the community structure of macroinvertebrates. Their use is based on the phenomenon that relatively unpolluted environments support communities having large numbers of species with no individual species present in overwhelming abundance. If the species in such communities are ranked on the basis of their numerical abundance, there will be relatively few species with large numbers of individuals and large numbers of species represented by only a few individuals.

The equitability (e) component of species diversity was also computed (Lloyd and Ghelardi 1964). Equitability indices compare numbers of species (s) in a sample with the number of species expected (s′) and are very sensitive to slight levels of water pollution.

Equitability was computed from:

$e = s'/s$ where:
- s = number of taxa
- s′ = table value from Lloyd and Ghelardi (1964)

Periphyton (mainly algae and detritus) was collected monthly at all sites on Trout Creek (except sites 2 and 5 in June which had recently installed rubble) using a timed scraping technique (Ward 1974). One sample per site was collected monthly. Periphyton was removed from the upper surfaces of rubble and the samples were preserved in 5% formalin and transported to a laboratory for determination of relative abundance and distribution of common genera. The percentage (based upon numbers) of microscopic algae and detritus in the sample was measured utilizing a grid under a microscope at 400X. Comparison of the percentages of macroscopic algae to the microscopic algae/detritus fraction was estimated using a dissecting microscope. Percentage composition of diatoms was determined by counting two hundred valves. Dry weight was obtained after oven drying at 60°C for 12 hours. Loss on ignition values were obtained by ashing for 1 hour at 600°C in a muffle furnace.

Fish were collected at all sites on Trout Creek in early September with a backpack DC electroshocker or by seining (fig. 4). Effort was made at each site to insure that general comparisons could be made concerning abundance and composition at the different locations. However, different habitat conditions at different locations influenced sampling efficiency to some degree. Fish were identified and their numbers recorded.

Figure 4.—Fish were collected with a backpack DC electroshocker and by seining.

Water temperature was determined at the time of sampling at each site with a mercury in glass thermometer (accurate to ± 0.1°C). An intensive study of selected physical and chemical parameters of the water was also conducted during the same field season at each study site. Water analysis was done according to

Table 1. Physical and chemical parameters of all sampling locations

Parameter	Study site 1	2	3	4	5	6	7	8	9
Discharge (l/s)	12.6	16.2	23.2	30.0	20.5	2.2	1.3	0.6	0.6
Conductivity ($\frac{\mu mhos}{cm}$)	230	270	217	247	253	140	151	110	123
Total dissolved solids (mg/l)	169	200	130	173	205	106	97	89	97
Total suspended solids (mg/l)	21	25	24	22	21	15	23	22	28
Turbidity (NTU)	3.4	11.6	4.9	3.3	9.3	0.9	2.8	2.4	3.0
pH	8.1	7.8	8.3	7.8	7.6	7.7	7.9	7.2	7.5

one of the accepted procedures outlined in Standard Methods (American Public Health Association, Inc. 1976).

Results and Discussion

A summary of physicochemical data for water samples collected at each study site is given in table 1. The values are average concentrations for weekly samples taken during the period June-October. Most of the physical and chemical parameters exhibited great temporal variation; however, some general trends which could potentially affect macroinvertebrates are indicated by the data. Reductions in dissolved solids and conductivity between sites 2 and 3 indicate that the reservoir may act as a settling basin for some of the chemical constituents. This tends to distort the typical longitudinal zonation of these factors observed in many streams (Hynes 1970). The intermittent streams conform more to the usual situation with the lower sites 7 and 9 generally showing increases in the various parameters compared to the upstream values for sites 6 and 8 (table 1).

The temperature data are presented in table 2. Well-shaded sites such as 1, 6, 7, 8, and 9 generally exhibited temperatures that were much lower than those in the more open reaches such as the reservoir and meadow areas (sites 2, 3, 4, and 5).

Table 2. Temperature data (°C) at all sites for the sampling period

Month	Study site 1	2	3	4	5	6	7	8	9
June	3.5	10.0	12.0	11.0	11.0	6.0	8.0	4.0	5.5
July	6.5	13.0	14.5	14.0	14.5	7.5	9.0	6.0	9.0
Aug.	6.5	11.0	14.5	15.0	19.0	9.0	11.0	6.5	9.5
Sept.	6.8	10.5	13.0	11.5	11.5	7.0	8.0	6.0	8.0
Oct.	0.5	3.0	4.0	4.5	6.0	2.5	2.0	4.0	4.0

Table 3 presents dry weight (standing crop) and loss on ignition values for the periphyton samples collected from the Trout Creek sites. Loss on ignition values approximate the organic contribution. Generally, the lower values were obtained at the upper two sites and the higher at site 3 below the dam. The more constant flow conditions encountered below the reservoir probably allowed this greater development. The absence of a canopy of vegetation over the stream allowed more incident solar radiation to reach the stream, which, combined with higher temperatures, may also have contributed to the increased growth below the dam. In a study on the South Platte River, Ward (1976a) also found a greater standing crop of periphyton below a reservoir.

Table 3. Periphyton standing crop (mg/l-minute scraping) at Trout Creek study sites

Month	Biomass	Study site 1	2	3	4	5
June	Dry weight	80.5	----	89.9	336.9	----
	L.O.I.[1]	20.5	----	28.0	29.7	----
July	Dry weight	8.1	9.4	254.4	11.1	81.6
	L.O.I.	1.4	0.8	86.6	2.3	20.0
Aug.	Dry weight	97.3	42.1	401.5	4.6	382.4
	L.O.I.	13.9	7.7	163.1	1.1	67.1
Sept.	Dry weight	216.5	119.3	1140.5	270.0	177.4
	L.O.I.	70.9	9.5	572.4	30.9	45.9
Oct.	Dry weight	479.5	298.8	2714.6	389.0	532.5
	L.O.I.	84.8	41.8	688.2	88.9	136.9

[1]L.O.I. = Loss on ignition.

Composition of the total periphyton varied according to date and site (appendix A). Major components were algae, detritus, and a bryozoan (*Plumatella*). The bryozoan occurred only at site 3, immediately below the dam. Bryozoans are filter-feeders; their presence below the dam undoubtedly relates to the limnetic seston (organic matter in suspension) supplied by the reservoir.

Composition of the algae also varied greatly according to site and date (appendices B-D). A total of 57 genera from 6 divisions were collected. Chlorophyta (green algae) was the most abundant division collected at site 1. *Cladophora* was very abundant and is a typical filamentous green alga encountered in streams, especially those somewhat high in nutrients. Rhodophyta (red algae) was the most prevalent division at site 2 with *Batrachospermum moniliforme* being the sole representative. Bacillariophyta (diatoms) was generally the most abundant division collected at site 3. In September however, green algae were more prevalent—possibly due to warmer summer temperatures and a resultant reduction of diatom populations. *Diatoma vulgare,* the dominant component of the diatom community during the cooler months, is favored by cold water temperatures (Lowe 1974). Diatoms present throughout the study period included *Gomphonema* spp., *Navicula* spp., and *Nitzchia* spp. These genera have species with wide tolerance limits to many environmental factors (Lowe 1974). Certain lentic forms, such as *Dinobryon* and *Pediastrum,* were often collected at sites below the reservoir and were probably the result of inadvertent downstream movement. Sites 4 and 5 were generally dominated by *Cladophora* and, on occasion, *Batrachospermum.*

Table 4 summarizes the data collected on macroinvertebrates from the Trout Creek sites.

Table 4. Macroinvertebrate parameters at Trout Creek study sites for entire sampling period

Parameter	Study site 1	2	3	4	5
Density (org/m^2)	4112	1575	12903	3373	2184
Biomass (g wet wt/m^2)	11.2	8.5	95.5	24.3	11.3
Diversity ($\bar{d}$)	4.14	3.77	1.74	3.62	3.30
Equitability (e)	0.70	0.59	0.16	0.67	0.54

Mean density of individual taxa from Trout Creek sites is presented in appendix E; biomass of major groups by site and date is shown in appendix F.

A system for the classification of streams based on densities of benthic macroinvertebrates has been formulated by the U.S. Fish and Wildlife Service, mainly as it relates to fish production (Madsen 1935). Streams with less than 1,076 organisms/m^2 are considered to be poor; 1,076-2,152 organisms/m^2 are rated medium; and streams with more than 2,152 organisms/m^2 are classified as rich. All Trout Creek sites are rich except site 2 (table 4). Furthermore, the density values are in the range typically found in Colorado streams (Ward 1975a, Canton and Ward 1977) except for site 3. The tremendous increase in density at site 3 was the result of increased populations of *Cheumatopsyche* sp. and *Simulium arcticum.* These two taxa accounted for over 90% of the individuals collected at site 3. Both are primarily filter-feeders and their great abundance may be a response to discharge of limnetic seston from the reservoir (Ward 1975b).

Table 4 also presents data on standing crop (biomass). A classification scheme has been proposed which relates biomass to the richness of the stream. Streams with bottom fauna standing crops less than 11 g/m^2 (wet weight) are considered poor; 11-22 g/m^2 are rated medium; and those greater than 22 g/m^2 are classified as rich (Hazzard 1935). Thus sites 1 and 5 would be classified as medium, site 2 as poor, and sites 3 and 4 would be considered rich. The reservoir also exerted a considerable effect on biomass by enhancement of filter-feeding taxa resulting in a mean biomass of 95.5 g/m^2 at site 3. The relatively high biomass at site 4 was due to occasional high populations of large crane fly (Tipulidae) larvae.

Unpolluted streams usually have diversity ($\bar{d}$) values between 3.0 and 4.0 (Wilhm 1970) and equitability values (e) from 0.6 to 0.8 (Weber 1973). Only site 3 below the dam deviated significantly from these values (table 4). Macroinvertebrate communities below dams often have diversity and equitability values which resemble those associated with mild organic pollution, although other environmental stresses are involved (Ward 1974, 1976a, 1976b). The remaining Trout Creek sites

appeared relatively free of environmental degradation as indicated by diversity and equitability values.

Composition of the macroinvertebrate communities varied according to site. The percentage composition of the major groups is shown in figure 5. Plecoptera (stoneflies) were the most

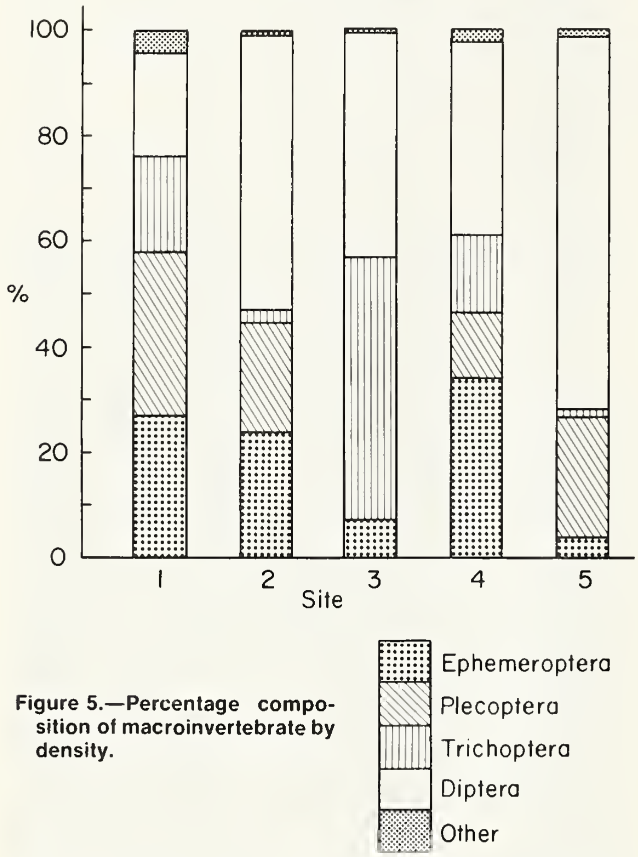

Figure 5.—Percentage composition of macroinvertebrate by density.

abundant group in terms of numbers present at site 1 with six taxa accounting for 31.1% of the macroinvertebrate community. Ephemeroptera (mayflies) were also abundant at this site, composing 26.8% of the community and were represented by seven taxa. Trichoptera (caddisflies) were also well represented at site 1. Seven taxa of caddisflies were identified, accounting for 18.0% of the macroinvertebrates. Diptera (true flies) exhibited the greatest community development at site 1 with a total of 12 taxa representing 19.4% of the total fauna. At site 2, mayfly, stonefly, and caddisfly populations were reduced compared to site 1 with a resulting increase in the dipterans. Community structure at site 3 varied greatly from site 1. No stoneflies were collected at site 3 during the entire sampling period. Mayflies were greatly reduced in number and diversity while caddisflies and dipterans comprised over 90% of the macroinvertebrate community. As previously mentioned, this was due to a high build-up of filter-feeding taxa. The absence of stoneflies at this site is likely related to the influence of the reservoir, since stonefly populations increased with distance from the dam in both upstream and downstream directions. Dipterans were the dominant organisms at sites 4 and 5 with a more balanced community present at site 4. Dipterans were represented to a great extent at these lower sites by chironomids (midges). Chironomidae is a very ubiquitous and diverse family containing many species which tolerate a wide range of environmental conditions (Hynes 1970).

Some taxa of macroinvertebrates were restricted to certain sites whereas others were more widely distributed (appendix E). The mayflies *Ephemerella inermis* and *Baetis* sp. were collected at every location except site 5 where *E. inermis* was absent. *E. inermis* is a species found in many locations and environmental situations throughout the western United States (Allen and Edmunds 1965). Another mayfly, *Tricorythodes* sp., was collected at all sites except site 1. *Tricorythodes* is well adapted for somewhat silty conditions through its modified first gill, which is operculate and thus protects the remaining gills from fouling. Increased siltation at lower sites may favor this mayfly; the distribution of rooted aquatic plants may also influence its distribution by providing refugia from the stream current (Ward 1976a). Trichopterans seemed to be more restricted in their distribution. *Rhyacophila* spp. were collected only at site 1, *Hydroptila* sp. only at site 4, and *Glossosoma* sp. were largely confined to site 1.

Only qualitative samples were taken from the two intermittent streams (sites 6, 7, 8, and 9). Taxa collected are listed in appendix G. A fairly diverse collection of macroinvertebrates was present in the intermittent streams. Several taxa (Empididae, *Parameletus* (columbiae ?), *Ephemerella coloradensis*, *Acroneuria* sp., *Ecclisomyia* sp., *Hesperophylax* sp., *Rhyacophila verrula*) were collected in the intermittent streams, but not in Trout Creek. The macroinvertebrate collections did not indicate a

significant impact on water quality as a result of the human habitation in the areas of the intermittent streams as taxa intolerant of pollution were collected.

Composition of the fish fauna is presented in table 5. Brook trout (*Salvelinus fontinalis*) was the dominant species at site 1. The greatest diversity occurred at site 3 with suckers (*Catostomus* spp.) occurring in the greatest abundance. After being somewhat depressed in number near the reservoir, numbers of brook trout increased at the lower sites. Brook trout collected in Trout Creek ranged in size from 6 to 25 cm. At sites 1-4 mean total lengths were similar (8-9cm). The largest trout were collected at site 5 where total lengths ranged from 8 to 25 cm with a mean of 16.5 cm.

Table 5. Composition of fish collected (nos./30-minute sampling effort) at Trout Creek study sites

Taxon	Study site 1	2	3	4	5
Brook trout *Salvelinus fontinalis*	19	4	5	13	15
Western longnose sucker *Catostomus catostomus*	2	0	19	5	13
White sucker *C. commersoni*	1	0	10	0	2
Immature suckers *Catostomus* spp.	0	1	43	0	6
Sand shiner *Notropis stramineus*	0	3	0	0	0
Speckled dace *Rhinichthys osculus*	0	8	15	0	0

Summary and Conclusions

A total of 57 genera of algae, 5 species of fish, and 78 taxa of macroinvertebrates were collected and identified.

Site 1 generally exhibited the most diverse mayfly (Ephemeroptera) stonefly (Plecoptera) and caddisfly (Trichoptera) communities. The species in these orders are important components of the aquatic food web in Trout Creek, and appear relatively sensitive to and intolerant of environmental changes. The macroinvertebrate community at site 1 was the most representative of local unpolluted streams, and provided an index to gage stream health and environmental impact at the other sites.

The biota at all other sites were influenced to some degree by the reservoir, beaver ponds, and stream silting which altered the substrate and water temperature. Limnetic seston (organic matter in suspension) derived from within the reservoir allowed the development of an extensive filter-feeding community below the spillway dominated mainly by two taxa of macroinvertebrates. This location had an extremely low diversity when compared to the other sites and may be indicative of a stressed situation. The relatively high diversities encountered at the other sites do not indicate any significant degradation of water quality. Community composition, however, differs between sites and suggests that conditions have changed in some way.

Some taxa occurred at most of the sampling sites while others were limited to a single location. Those taxa with limited distribution may prove useful as indicators of particular environmental conditions. Further investigation is needed to determine what these environmental conditions are and if they are the result of a particular type of land use practice.

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Appendices

Appendix A

Percent major periphyton components at Trout Creek Study sites.

Month	Periphyton	Study site 1	2	3	4	5
June						
	Algae	90	--	40	85	--
	Detritus	10	--	60	15	--
	Bryozoa	0	--	0	0	--
July						
	Algae	30	30	35	25	25
	Detritus	70	70	25	75	75
	Bryozoa	0	0	40	0	0
August						
	Algae	80	60	15	85	65
	Detritus	20	40	75	15	35
	Bryozoa	0	0	10	0	0
September						
	Algae	70	35	5	85	50
	Detritus	30	65	90	15	50
	Bryozoa	0	0	5	0	0
October						
	Algae	75	40	15	85	85
	Detritus	25	60	15	15	15
	Bryozoa	0	0	70	0	0

Appendix B

Percent algal components by months at Trout Creek study sites.

Month	Algae	Study site 1	2	3	4	5
June						
	Bacillariophyta	4	--	50	90	--
	Chlorophyta	96	--	35	5	--
	Chrysophyta	0	--	5	0	--
	Cyanophyta	[1]*	--	*	*	--
	Euglenophyta	0	--	0	*	--
	Rhodophyta	0	--	10	5	--
July						
	Bacillariophyta	90	50	50	5	10
	Chlorophyta	10	40	40	90	90
	Chrysophyta	0	0	6	0	0
	Cyanophyta	*	5	2	0	*
	Euglenophyta	0	0	2	0	0
	Rhodophyta	0	5	0	5	0
August						
	Bacillariophyta	15	8	60	10	5
	Chlorophyta	85	2	5	15	95
	Chrysophyta	0	0	10	0	0
	Cyanophyta	*	5	5	*	*
	Euglenophyta	0	0	10	0	0
	Rhodophyta	0	85	10	75	0
September						
	Bacillariophyta	25	5	10	10	2
	Chlorophyta	75	10	80	70	95
	Chrysophyta	0	0	2	0	0
	Cyanophyta	*	5	*	*	1
	Euglenophyta	0	0	10	0	0
	Rhodophyta	0	85	0	20	2
October						
	Bacillariophyta	15	10	20	10	2
	Chlorophyta	85	50	60	80	98
	Chrysophyta	0	0	5	0	0
	Cyanophyta	*	0	5	*	*
	Euglenophyta	0	0	10	0	0
	Rhodophyta	0	40	0	10	0

[1]* = less than 1.0 percent.

Appendix C

Percent periphyton by common algal genera at Trout Creek sites.

Genera and species	Study sites																								
	June					July					August					September					October				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Bacillariophyta																									
Amphipleura spp.	0	---	[1]*	10	---	5	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocconeis spp.	15	---	0	10	---	0	0	0	0	0	45	0	0	35	0	5	0	5	65	0	0	0	0	0	0
Cymbella spp.	0	---	0	40	---	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Diatoma vulgare	60	---	0	0	---	0	0	10	0	0	10	0	0	0	0	90	0	30	0	0	40	0	70	40	0
Fragilaria vaucheria	0	---	20	0	---	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphonema spp.	0	---	30	0	---	0	0	0	0	0	0	0	0	0	34	0	0	0	0	30	0	0	0	0	20
Navicula spp.	5	---	10	10	---	30	10	30	35	22	10	15	65	10	15	0	15	25	10	15	15	10	10	0	5
Nitzchia spp.	10	---	15	20	---	30	30	15	10	47	20	30	10	10	15	0	30	2	2	15	10	30	15	0	10
Synedra spp.	0	---	10	0	---	0	0	0	0	0	0	0	5	0	10	0	10	*	0	10	0	5	0	30	30
Achnanthes spp.	0	---	0	0	---	0	20	10	30	0	0	25	10	0	0	0	25	20	0	15	25	15	0	0	10
Surirella angustata	0	---	0	0	---	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Epithemia sorex	0	---	0	0	---	0	0	0	0	0	0	20	0	20	0	0	10	0	5	0	0	10	0	0	5
E. turgida	0	---	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Fragilaria spp.	0	---	0	0	---	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	0	0
Cyclotella sp.	0	---	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
	90		85	90		85	80	65	75	84	90	90	90	80	74	95	90	82	87	91	90	73	95	70	90
Chlorophyta																									
Cladophora sp.	99	---	0	0	---	0	0	0	0	0	99	0	0	85	0	98	0	75	30	0	95	0	75	0	0
Desmids	0	---	0	40	---	0	0	80	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhizoclonium sp.	0	---	98	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spirogyra sp.	0	---	0	60	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15	0
Chaetophora sp.	0	---	0	0	---	0	0	0	95	0	0	80	0	10	10	0	0	0	0	0	0	85	0	0	25
Stigeoclonium sp.	0	---	0	0	---	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulothrix spp.	0	---	0	0	---	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	5	0	0	0
Zygnema sp.	0	---	0	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Unidentified	0	---	0	0	---	75	60	0	0	95	0	0	0	0	85	0	60	15	60	90	0	0	0	70	70
	99		98	100		75	100	80	95	95	99	100	0	95	95	98	60	90	90	90	95	90	90	90	95
Euglenophyta																									
Trachelmonas spp.	0	---	0	100	---	0	0	20	0	0	0	0	75	0	0	0	0	85	0	0	0	0	0	0	0
Euglena spp.	0	---	0	0	---	0	0	75	0	0	0	0	15	0	0	0	0	0	0	0	0	0	90	0	0
Phacus sp.	0	---	0	0	---	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0		0	100		0	0	100	0	0	0	0	90	0	0	0	0	85	0	0	0	0	90	0	0
Rhodophyta																									
Batrachospermum sp.	0	---	100	100	---	0	100	0	100	0	0	100	100	100	0	0	100	0	100	100	0	100	0	100	0
Chrysophyta																									
Dinobryon sp.	0	---	100	0	---	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100	0	0
Cyanophyta																									
Anabaena sp.	0	---	80	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dactylococcopsis sp.	0	---	20	0	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oscillatoria sp.	0	---	0	0	---	0	0	0	0	0	0	15	0	75	0	0	0	0	0	0	0	0	0	0	0
Phormidium sp.	0	---	0	0	---	0	0	0	0	0	0	75	80	20	0	80	80	0	0	0	0	0	0	0	0
	0		100	0		0	0	0	0	0	0	90	80	95	0	80	80	0	0	0	0	0	0	0	0

[1]* = less than 1.0%

Appendix D

Distribution of periphytic algae in Trout Creek, Colorado.

Algae	Study Site 1					2				3					4					5			
	J	J	A	S	O	J[2]	A	S	O	J	J	A	S	O	J	J	A	S	O	J[2]	A	S	O
Division Bacillariophyta																							
Achnanthes spp.	+	+	+	+	+[1]	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
A. lanceolata																							
A. minutissima																							
Amphipleura sp.		+							+	+					+	+					+		
Amphiprora sp.										+													
Asterionella formosa										+	+			+									
Cocconeis	+	+	+	+	+		+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+
C. rugosa																							
C. pediculus																							
Cyclotella meneghiniana			+	+				+		+		+	+	+	+		+	+	+	+	+	+	+
Cymatopleura solea	+		+				+									+					+		
Cymbella spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Diatoma anceps															+								
Diatoma vulgare	+	+	+	+	+				+	+	+		+	+	+	+	+	+	+		+	+	
Diploneis elliptica															+		+				+		
Epithemia sorex							+	+	+	+	+	+	+	+	+	+	+	+	+				+
Epithemia turgida									+														
Fragilaria spp.	+		+			+				+	+			+	+		+	+	+	+		+	+
F. capucina																							
F. construens																							
F. leptostauron																							
F. vaucheriae																							
Frustulia rhomboides																	+						
Gomphonema spp.		+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+
G. angustatum																							
G. constrictum																							
G. parvulum																							
Gyrosima sp.			+		+																		
Melosira spp.	+	+	+							+	+	+		+	+						+		
M. varians																							
Meridon circulare	+	+	+	+	+	+					+			+									
Navicula spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
N. cryptocephala																							
N. exigua																							
N. pupula																							
N. radiosa																							
Neidium sp.														+	+	+							
Nitzschia spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
N. acicularis																							
N. dissipata																							
N. gracilis																							
N. palea																							
Pinnularia spp.	+	+	+				+		+					+	+	+	+				+	+	
P. mesolepta																							
Rhoicosphenia curvata	+	+			+		+						+	+									
Rhopalodia spp.							+		+				+	+		+	+	+			+		
R. gibba							+	+	+														
R. gibberula							+	+															
Stephanodiscus sp.															+								
Surirella spp.		+	+			+									+			+	+	+	+		
S. angustata																							
S. ovata																							
Synedra spp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
S. acus																							
S. ulna																							
Division Chlorophyta																							
Ankistrodesmus falcatus				+					+		+	+	+	+					+	+			
Chaetophora elegans							+	+	+							+	+		+		+	+	+
Cladophora sp.			+	+	+						+		+	+			+	+	+		+		
Closteriopsis sp.							+		+		+		+	+					+				
Closterium spp.	+		+	+	+						+	+								+	+	+	
Cosmarium spp.				+							+	+		+							+		
Oedogonium spp.					+																		
Pediastrum duplex							+		+		+			+	+		+		+				
Pediastrum tetras											+								+				
Rhizoclonium sp.									+	+													
Scenedesmus acuminatus								+			+	+	+	+		+	+		+	+	+		
Scenedesmus quadricauda							+		+	+	+	+	+	+	+			+		+			
Selenastrum spp.					+						+					+							
Spirogyra sp.														+	+				+				
Staurastrum sp.											+	+	+	+	+	+				+	+		
Stigeoclonium sp.						+																	
Tetraedon sp.											+												

Appendix D (cont.)

Distribution of periphytic algae in Trout Creek, Colorado.

	Study Site																						
	1					2				3					4					5			
	J	J	A	S	O	J[2]	A	S	O	J	J	A	S	O	J	J	A	S	O	J[2]	A	S	O
Tetrastrum sp.											+												
Ulothrix sp.		+			+		+		+				+						+				+
Unidentified filament (believed to be a green)		+		+	+	+							+					+	+	+	+	+	+
Volvocacean unicell																			+				
Zygnema sp.																			+				
Division Chrysophyta																							
Dinobryon spp.										+	+	+	+	+									
Division Cyanophyta																							
Anabaena spp.	+		+	+	+	+	+	+			+	+	+	+	+	+	+	+	+	+	+	+	+
Dactylococcopsis spp.		+					+	+				+		+	+				+				
Lyngbya sp.						+	+	+				+											
Merismopedia sp.				+																			
Oscillatoria spp.		+	+	+	+	+	+	+	+		+	+		+	+		+				+	+	
Phormidium sp.				+			+		+			+	+	+			+				+	+	
Division Euglenophyta																							
Euglena spp.								+			+	+	+	+									
Phacus sp.											+	+	+	+									
Trachelomonas spp.											+	+	+	+	+								
Division Rhodophyta																							
Batrachospermum moniliforme						+	+	+	+	+		+			+	+	+	+	+			+	

[1] + = present

[2] J2 = July

Appendix E

Mean number of organisms per m^2 at Trout Creek study sites for the sampling period.

Organism	Study sites 1	2	3	4	5
Ephemeroptera					
Ameletus sparsatus	4	0	0	0	0
Baetis sp.	610	50	133	691	23
Ephemerella grandis grandis	105	1	0	0	0
E. inermis	151	3	1	47	0
Epeorus longimanus	112	0	0	0	0
Paraleptophlebia memorialis	74	61	0	124	1
Rhithrogena hageni	46	0	0	239	0
Rhithrogena sp.	0	2	9	0	0
Tricorythodes sp.	0	256	781	40	53
	1102	373	924	1141	77
Trichoptera					
Brachycentrus americanus	62	18	0	61	5
Glossosoma sp.	259	0	1	0	0
Hydropsyche sp.	134	9	0	375	4
Lepidostoma sp. A	2	0	0	4	0
Lepidostoma sp. B	144	0	0	0	0
Rhyacophila angelita	85	0	0	0	0
R. acropedes	56	0	0	0	0
Cheumatopsyche sp.	0	5	6398	0	0
Oecetis sp.	0	0	4	0	0
Anagapetus sp.	0	0	0	25	0
Hydroptila sp.	0	0	0	48	0
	742	32	6403	513	9

Appendix E (cont.)

Mean number of organisms per m^2 at Trout Creek study sites for the sampling period.

Organism	Study sites 1	2	3	4	5
Plecoptera					
Alloperla sp.	896	133	0	379	497
Amphinemura venusta	101	0	0	14	0
Isoperla sp.	1	5	0	26	0
Malenka californica	93	171	0	0	0
Nemoura spp.	188	0	0	0	0
Pteronarcella badia	2	0	0	0	0
	1281	309	0	419	497
Diptera					
Cricotopus sp.	92	0	0	0	303
Dicranota sp.	109	0	6	0	0
Heterotrissocladius sp.	22	79	159	0	0
Hexatoma sp.	2	9	0	206	82
Palpomyia sp.	2	22	0	35	24
Pericoma sp.	193	5	1	0	0
Procladius sp.	89	200	0	61	104
Rheotanytarsus sp.	161	112	0	252	216
Simulium arcticum	26	163	4922	570	515
Thienemanniella sp.	66	166	0	33	0
Tipula sp.	25	10	14	12	6
Tribelos sp.	10	0	25	0	0
Atherix variegata	0	12	0	0	24
Micropsectra sp.	0	10	14	0	0
Monodiamesa sp.	0	14	0	0	0
Ablabesmyia sp.	0	0	90	0	0
Antocha sp.	0	0	4	0	0
Eukiefferiella sp.	0	0	186	0	92
Cardiocladius sp.	0	0	0	0	46
Tabanus tabanus	0	0	0	0	36
	797	802	5421	1169	1448
Coleoptera					
Optioservus sp.	164	1	13	22	19
Agabus sp.	0	1	0	0	1
Zaitzevia sp.	0	10	7	50	7
Helichus sp.	0	0	0	0	2
	164	12	20	72	29
Collembola					
Entomobrya sp.	2	0	0	0	0
Turbellaria					
Polycelis coronata	12	0	2	0	0
Nematoda	11	0	29	0	0
Oligochaeta					
Eiseniella tetraedra	2	0	4	1	0
Limnodrilus sp.	0	0	0	0	1
	2	0	4	1	1
Odonata					
Ophiogomphus severus	0	2	0	11	7
Hydracarina					
Lebertia sp.	0	13	0	11	1
Amphipoda					
Hyallela azteca	0	6	27	0	0
Gastropoda					
Helisoma sp.	0	3	17	17	28
Lymnaea sp.	0	1	0	0	0
Physa sp.	0	12	22	21	89
	0	16	39	38	117
Hirudinea					
Helobdella stagnalis	0	6	9	0	0
Hemiptera					
Gerris sp.	0	0	6	0	0
Rhagovelia sp.	0	0	3	0	0
	0	0	9	0	0
Decapoda					
Orconectes sp.	0	0	1	0	0

Appendix F

Biomass (g wet wt/m^2) of macroinvertebrates at Trout Creek sites.

Organism	June	July	August	September	October
Site 1					
Ephemeroptera	4.0	3.4	1.7	2.3	3.4
Trichoptera	3.7	4.0	2.0	2.3	5.7
Plecoptera	1.3	1.7	0.7	4.4	5.4
Diptera	1.3	0.9	2.0	2.6	1.7
Coleoptera	0.7	0.3	0.1	0.3	0.3
	11.0	10.3	6.5	11.9	16.5
Site 2					
Ephemeroptera	1.4	2.6	2.2	0.1	0.4
Trichoptera	1.5	0.5	T	T	0
Plecoptera	1.8	0.9	0.2	T	0.2
Diptera	15.6	7.2	0.8	0.5	0.3
Coleoptera	[1]T	T	T	0	T
Odonata	0	0	5.4	0	0
Gastropoda	T	T	T	1.1	T
	20.3	11.2	8.6	1.7	0.9
Site 3					
Ephemeroptera	1.7	8.0	2.0	1.0	1.0
Trichoptera	42.9	17.2	48.2	155.8	63.3
Plecoptera	0	0	0	0	0
Diptera	34.5	64.1	5.0	11.1	4.0
Coleoptera	T	T	0	T	T
Gastropoda	0	T	0	0	1.7
Hirudinea	1.4	0	0	11.1	1.0
Oligochaeta	0.7	2.0	0	0	0
	81.2	91.3	55.2	179.0	71.0
Site 4					
Ephemeroptera	8.3	4.8	1.4	0.4	2.9
Trichoptera	5.4	0.7	1.1	5.4	9.0
Plecoptera	4.2	2.7	1.4	0.5	3.2
Diptera	23.8	12.1	3.2	4.9	11.2
Coleoptera	T	0.2	T	0.1	0.1
Gastropoda	0.4	0.4	1.1	2.5	T
Oligochaeta	0	0	0	0	0.7
Odonata	0	3.1	1.8	4.5	0
	42.1	24.0	10.0	18.3	27.1
Site 5					
Ephemeroptera	0.4	0.7	0.2	0.4	T
Trichoptera	T	0	T	T	T
Plecoptera	0	1.1	0.4	0.9	0.2
Diptera	12.6	6.5	3.2	2.7	2.5
Coleoptera	0	T	0.5	0.2	T
Gastropoda	0	2.2	1.2	18.4	0
Odonata	0	0.4	0.4	1.3	0
	13.0	10.9	5.9	23.9	2.7

[1]T = <0.1 g/m^2

Appendix G

Macroinvertebrate taxa collected from intermittent streams.

Organism	Hotel Gulch Site 6	Hotel Gulch Site 7	White Spruce Gulch Site 8	White Spruce Gulch Site 9
Ephemeroptera				
Baetis sp.	P[1]	P	P	P
Paraleptophlebia memorialis	P			
Cinygmula sp.	P	P	P	P
Ephemerella sp.			P	
E. coloradensis	P	P	P	
Ameletus sparsatus	P		P	
Epeorus longimanus	P			
Parameletus (*columbiae* ?)				P
Paraleptophlebia debilis				P
Rhithrogena robusta	P			
Plecoptera				
Acroneuria sp.	P			
Alloperla sp.	P		P	P
Amphinemura sp.	P		P	P
Leuctra sp.	P			
Visoka cataractae	P			
Zapada cinctipes	P		P	
Trichoptera				
Brachycentrus sp.	P	P	P	
Ecclisomyia sp.	P			P
Hesperophylax sp.		P		P
Lepidostoma sp.	P	P	P	P
Limnephilus sp.			P	P
Rhyacophila acropedes	P	P	P	
R. pupae	P			
R. verrula	P			
Diptera				
Atherix variegata		P		P
Cardiocladius sp.	P			
Cricotopus sp.	P			
Empididae	P		P	P
Eukiefferiella sp.		P		P
Palpomyia sp.			P	
Procladius sp.				P
Rheotanytarsus sp.	P			
Simuliidae		P		
Simulium sp.	P		P	P
Tipula sp.		P	P	P
Coleoptera				
Narpus sp.	P			
Optioservus sp.	P	P	P	P
Pelecypoda				
Pisidium sp.	P			
Gastropoda				
Gyraulus sp.			P	
Turbellaria				
Polycelis coronata	P		P	P
Hydracarina				
Lebertia sp.				P
Oligochaeta				
Lumbricus rubellus		P		

[1]P = present.

Agriculture—CSU, Fort Collins

Short, Robert A., James V. Ward, Howard L. Gary, and Pat O. Currie. 1978. Aquatic biota of Trout Creek, Manitou Experimental Forest, Colorado. Gen. Tech. Rep. RM-54, 13 p. Rocky Mt. For. and Range Exp. Stn., For. Serv., U.S. Dep. Agric., Fort Collins, Colo. 80521.

A survey of macroinvertebrates, periphyton and fishes in Trout Creek and in two of its tributaries was conducted from June through October 1976. Identified were 57 genera of algae, 5 species of fish and 78 taxa of macroinvertebrates. A generally diverse and abundant aquatic fauna and flora prevailed at most study locations. A site below a surface-release reservoir (Manitou Lake) exhibited reduced macroinvertebrate diversity, although standing crop was enhanced, presumably due to contributions of limnetic seston from the lake, compared with other sites on Trout Creek. Species diversity and equitability index values did not indicate any significant degradation of water quality.

Keywords: Periphyton, fishes, macroinvertebrates, water quality, stream biology.

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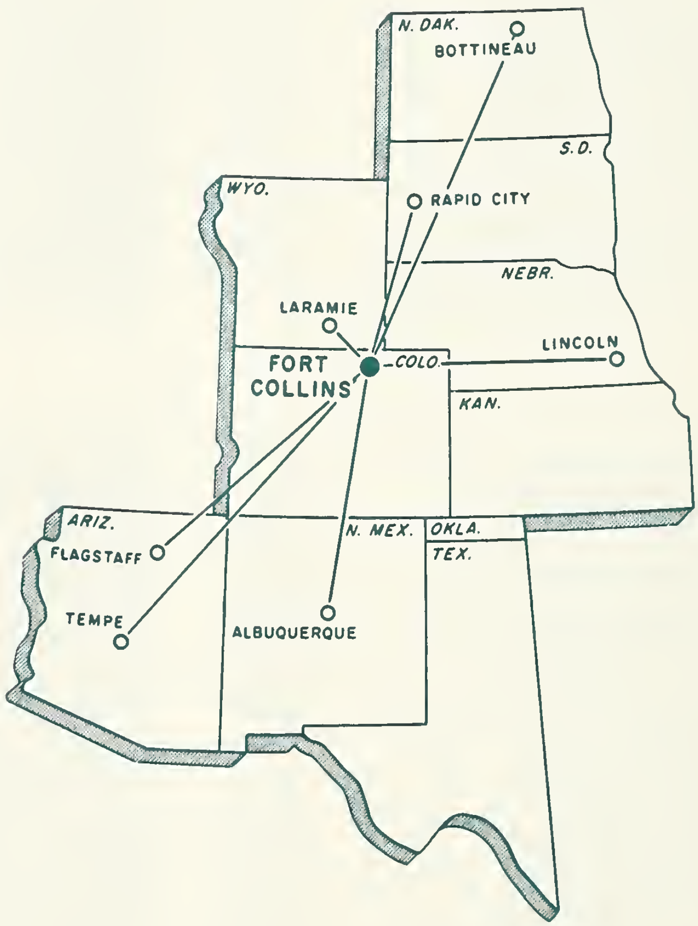
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